7th Symposium on Frequency Standards & Metrology
Summary for an Invited Presentation

The Semiclassical Stochastic-Field/Atom Interaction Problem*

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Contrary to the impression often given in standard texts that discuss semiclassical radiative interactions, no field in nature is truly monochromatic. Fluorescence and phosphorescence have emission bands that correspond to atomic and molecular energy level spacings and lifetimes, while the incandescence of lamps, sunlight and the cosmic microwave background are by definition broad band. Even "singlemode" lasers are not truly monochromatic, though they come quite close, since the single mode will have a spectral width that depends on a lasing photon's average lifetime in the cavity, and amplified-spontaneous-emission modes near the lasing mode will (at some level) produce fluctuations in the laser's output. The question then for metrology is twofold: at what level of measurement precision (or stability) does a semiclassical field's stochastic nature become relevant, and how does the field's stochastic nature manifest itself in the measurements. At the present time, answers to these questions are only known in a few specific cases, and general intuitive models are lacking. What is known is that the stochastic nature of a field can have subtle but significant effects, influencing both the quantitative and qualitative nature of the field/atom interaction.

This presentation will provide an overview of the semiclassical stochastic-field/atom interaction, which is to be contrasted to the ("intrinsically stochastic") quantum-field/atom interaction. Highlighting previous research, it will illustrate how the stochastic nature of a semiclassical field can have a significant effect on spectroscopic signals, and that these effects are not always intuitively obvious. In addition to considering the effect of a field's non-monochromaticity on resonance linewidths, the presentation will include a discussion of the stochastic field's role in limiting spectroscopic signal-to-noise ratios. Finally, the question of where we go next in understanding the stochastic-field/atom interaction will be addressed. In particular, it will be argued that while theoreticians have taken the lead in studying this problem, thoughtful experimental studies are few and far between. More importantly, perhaps, we need to develop intuitive models of the stochastic-field/atom interaction, which will indicate when the conditions are ripe for stochastic-field effects to manifest themselves, and also what those effects are likely to be.

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